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Fail-safe interfacing of a network element with a communication network

In order to ensure that a telephone service is as readily available as in conventional TDM telephone networks (TDM = Time Division Multiplex) when IP networks (IP) are used as a transmission network, media gateways (trunk gateways, access gateways) have to be connected in a fail-safe manner to a network of IP routers.

The failures that have to be taken into account comprise partial failures of the media gateway (MG), total or partial failures of IP routers, and failures of the connections between the media gateway and the IP routers. Fail-safe interfacing of a media gateway with IP routers ensures unimpaired functioning of the entire system if one of said failures occurs.

Known possibilities for implementing fail-safe connections between a media gateway and IP routers are illustrated in Figures 1A and 1B. In order to avert the failure of central components within the media gateway, all central components of the media gateway are duplicated. By way of example, Figure 1 shows a duplicated Ethernet switch ES0, ES1, by means of which the switching of data between the media gateway MG and the IP network IP is executed. One of the duplicated components is thereby active in each instance and the other inactive. In the example illustrated, the first Ethernet switch ES0 is active and the second Ethernet switch ES1 inactive. The operating state of an inactive component, in this case the Ethernet switch ES1 for example, is also referred to as 'standby' since in the event of failure of the active component, this inactive component immediately takes over its functions. The set of active components is subsequently referred to as the 'active half' and the set of inactive components as the 'inactive half'.

The media gateway MG is connected to two edge routers ER01, ER1 of the IP network IP. To this end, the media gateway MG comprises a plurality of independent connections; in the example shown in Figure

1A these are the two independent connections L0 and L1. Both the active and the inactive halves of the media gateway MG are thereby connected to the IP network IP via separate connections L0, L1. The first connection L0 connects the first, active Ethernet switch ES0 to the first edge router ER0 of the IP network IP. The second connection L1 connects the second, inactive Ethernet switch ES1 to the second edge router ER1 of the IP network IP. The first connection L0 is thus the active connection, while the second connection L1 is the inactive connection or standby connection. The terms 'active' and 'inactive' relate to the transport and switching of payload data, whereby an inactive connection is for example fully active physically but does not transport any payload data.

In the case of an exemplary media gateway MG with 2000 (voice telephony) ports each having a data rate of 64 kbps and IP packets, which each transport 10ms of digitized voice, data is transmitted between the media gateway MG and the IP network IP, in the example in Figure 1 on the active connection L0, at an approximate data rate of 220 Mbps.

As already mentioned, in Figure 1A each half of the media gateway MG is connected to a respective router ER0, ER1, by means of one Gigabit Ethernet connection L0, L1 in each instance. In contrast to this, in a further known configuration according to Figure 1B, each half of the media gateway MG is connected respectively to both routers ER0, ER1 by means of a total of four Gigabit Ethernet connections L0,L1,L2,L3. In comparison with Figure 1A, the following connections are thereby additionally required; the connection L01 between the first Ethernet switch ES0 of the media gateway MG and the second edge router ER1 of the IP network IP, the connection L10 between the second Ethernet switch ES1 and the first edge router ER0. In the configuration shown in Figure 1B for interfacing the media gateway MG with the IP network IP, only the first connection L0 is active, all other connections L1, L01, L10 are inactive connections or standby connections.

The following problems result in respect of the known possibility of fail-safe inferfacing in accordance with Figure 1A,:

- Only a fraction (approximately 220Mbps) of the total available connection capacity of 1Gbps x 2 is used. Even if the active connection L0 is fully utilized with corresponding expansion of the media gateway MG, utilization of the total available transmission capacity can never exceed 50%.
- The redundant parts of the media gateway MG and the respective connected edge routers ER0, ER1 form what is termed a failure unit. Consequently availability is reduced, because 'crossover failure', in other words simultaneous failure for example of the first Ethernet switch ES0 and the second edge router ER1, results in total failure of the interfacing of the media gateway MG with the edge routers ER0, ER1.
- Internal failures of the media gateway MG are visible in the IP network IP. A distinction is typically made between the operator of the media gateway MG and the operator of the IP network IP and it is desirable for the operator of the media gateway MG not to give any external indications which allow conclusions to be drawn about the availability/reliability of their systems.
- Protection switching either requires rerouting of the data traffic in the IP network IP, which is associated with long response times, or a link EL1 between the edge routers ER0, ER1, shown in Figure 1A with a dashed line. This additional connection however renders the interfacing of the media gateway MG with the IP network IP more expensive.

The following problems result in respect of the known possibility of fail-safe interfacing in accordance with Figure 1B,:

- The functional disadvantages of the configuration according to Figure 1A are avoided by this configuration in that 'crossover interfacing' is implemented, so that 'crossover failure' does not result in total interfacing failure. Nevertheless in contrast to

the configuration according to Figure 1A, an even smaller proportion of the total available connection capacity of 4 x 1Gbps is used. Utilization of the total available transmission capacity can never exceed 25% even with full utilization of the active connection L0 with corresponding expansion of the media gateway MG. An interfacing operation according to Figure 1B is therefore not acceptable from an economic point of view, since the costs per connection are not a function of their utilization, as explained below.

Conventional routers offer 'wire speed throughput', in other words the (computing) power of the router is designed such that all interfaces can be operated at the data rate supported by the connected transmission medium and traffic restrictions do not occur. As a result the routers only have a limited number of interfaces, since otherwise 'wire speed' cannot be guaranteed. The connection costs relating to data rate therefore increase significantly in the case of a low utilization level due to the absence of concentration capability, for example four times the costs relating to data rate result with 25% utilization of a connection compared with 100% utilization of the same connection.

One object of the present invention is to propose a method for the fail-safe interfacing of a network element with a communication network and a network element having fail-safe interfacing with a communication network, thereby avoiding the disadvantages of the prior art.

This object is achieved using a method for the fail-safe interfacing of a network element with a communication network according to the features of Claim 1 and a network element having fail-safe interfacing with a communication network according to the features of Claim 10.

Preferred embodiments are the object of the dependent Claims.

According to the present invention, a method is provided for the fail-safe interfacing of a network element MG having a network element (MG) comprising at least one component which is configured in an at least doubly redundant manner with a communication network IP by coupling each of at least two interface units IF0, IF1, IF2, IF3 to a component ER0, ER1, ER2, ER3 of the communication network IP via one respective connection L0, L1, L2, L3 and to the redundant components ES0, ES1 of the network element MG via one respective connection.

According to the present invention, a network element MG having fail-safe interfacing with a communication network IP is also provided comprising at least one component ES0, ES1 which is configured in an at least doubly redundant manner, comprising at least two interface units IF0, IF1, IF2, IF3 each having a connection L0, L1, L2, L3 to one respective component ER0, ER1, ER2, ER3 of the communication network IP and one respective connection to the redundant components ES0, ES1 of the network element MG.

Based on the smallest configuration of the invention, wherein two interface modules IF0, IF1 are each connected to a respective component ER0, ER1 of the communication network IP each via one respective connection L0, L1, 'crossover failure' advantageously does not result in total failure, in contrast to the configuration shown in Figure 1A. By way of example the active component ES0 and additionally one of the interface modules IF0, IF1 or one of the connections L0, L1 or one of the components ER0, ER1 of the communication network can fail without resulting in total failure. In contrast to the configuration shown in Figure 1B, this is achieved by deploying two instead of four connections L0, L1. The solution according to the invention thereby achieves a higher failure safety than the solution according to Figure 1A, and is at the same time clearly more cost-effective with regard to the transmission capacity to be made permanently available than the solution according to Figure 1B, since even in the smallest inventive configuration

utilization of the connection is up to 50% in comparison with 25% as shown in Figure 1B.

According to the present invention, it is advantageously possible to interface via more than two connection groupings. (The term connection grouping is introduced here to mean the grouping comprising the interface unit IF0, IF1, IF2, IF3, assigned connection L0, L1, L2, L3 and assigned component ER0, ER1, ER2, ER3 of the communication network IP, since these form a failure unit, in other words for the purpose of interfacing the failure of an interface unit or the assigned connection or the assigned component of the communication network is equivalent). In association with Claim 2, the advantage then results that interfacing can take place with (N+1) connection groupings, whereby N is the minimum number of separate connections required simultaneously, in order to supply the required overall transmission rate for the interfacing. For example, N=3 connections of the fast Ethernet type (with a capacity of 100Mbps each) are required as a minimum for fail-safe interfacing with a transmission capacity of 220Mbps and according to the invention N+1=4 connection groupings should be provided.

A further advantage of the invention is that the present invention allows the distribution of fail-safe interfacing to low-speed connections, for example 4 fast Ethernet connections instead of 2 Gigabit Ethernet connections, thus allowing cost-effective interfacing since a plurality of low-speed connections is generally more cost-effective than a high-speed connection, the capacity of which is for example less than 30% used.

The invention is described below in more detail with reference to three Figures as exemplary embodiments.

Figure 1A shows in schematic form the known interfacing of a network element with a communication network, whereby each redundant half of the network element is connected to the communication network via one respective connection.

Figure 1B shows in schematic form a known interfacing of a network element with a communication network, whereby each redundant half of the network element is connected to the communication network via two respective connections. Figure 2 shows in schematic form the inventive interfacing of a network element with a communication network, whereby each redundant half of the network element is connected to the communication network via a plurality of connection groupings to establish the connection.

Figures 1 and 2 each show a media gateway MG, which is connected on the one hand to a conventional telephone network by means of a TDM method and is to be connected on the other hand to a communication network IP. As already mentioned, Figures 1A and 1B show different methods of the prior art for interfacing a network element MG with a communication network IP. The communication network IP is a packet-oriented communication network for example. An important transmission protocol for packet-oriented networks is the Internet protocol.

In addition to other components (not shown) the media gateway MG has a multiplexer MUX by means of which TDM data is distributed to a plurality of TDM/IP converters TDM/IP. These converters are connected to the Ethernet switches ES0, ES1 via internal connections of the media gateway MG. As already described, one of the duplicated Ethernet switches ES0, ES1 is active, the other inactive. In the example shown, the first Ethernet switch ES0 is active and the second Ethernet switch ES1 is inactive or in standby mode. Further elements (not shown) of the media gateway MG can also be duplicated in order to increase the failure safety of the media gateway MG. The set of active elements is referred to as the 'active half', as already mentioned, the set of inactive elements being referred to as the 'inactive half'. If an active element fails, the assigned inactive element is activated automatically or further controlled by means of administrative intervention and assumes the role of the hitherto active element.

Figure 2 shows an exemplary embodiment of the inventive interfacing of a media gateway MG with the IP network IP. Four interface units IF0, IF1, IF2, IF3 which are components of the media gateway MG, are connected to both the active Ethernet switch ES0 and the inactive Ethernet switch ES1, via internal connections of the media gateway MG. Each interface unit IF0, IF1, IF2, IF3 is assigned precisely one connection L0, L1, L2, L3 to the IP-network, connecting each interface unit IF0, IF1, IF2, IF3 to a respective edge router ER0, ER1, ER2, ER3 of the IP network IP.

The use of a multiplier or a packet splitter at or in each interface unit IF0, IF1, IF2, IF3 of the media gateway MG means that only a respective common connection L0, L1, L2, L3 is required to connect both the active and also the inactive halves of the media gateway MG to the IP network IP. Packet splitters are used to forward the Ethernet frames coming in from the edge router ER0, ER1, ER3 to the active Ethernet switch ES0 in each instance and conversely to route the Ethernet frames coming in from the active Ethernet Switch ES0 to the edge router ER0, ER1, ER2, ER3.

In an alternative embodiment, Ethernet frames coming in from the edge router ER0, ER1, ER2, ER3 are duplicated and always forwarded to both Ethernet switches ES0, ES1 and the inactive Ethernet switch ES1 rejects the incoming Ethernet frames. In the reverse transmission direction the Ethernet frames coming in from the Ethernet switches ES0, ES1 are always forwarded to the edge router ER0, ER1, ER2, ER3. In this case it must be ensured that only one Ethernet switch ES0, ES1 is active at any time, in other words sending data to the edge routers ER0, ER1, ER2, ER3.

So that the telephone service is not impaired even in the event of connection failure or (even partial) failure of the edge router ER0, ER1, ER2, ER3, the payload is distributed to a

plurality of connections L0, L1, L2, L3, to four connections in Figure 2 for example.

The example already mentioned is used as a numerical example (2000 ports each with a data rate of 64 kbps and IP packets, which each transport 10ms of digitized voice, resulting in a data rate of approximately 220Mbps between the Media gateway MG and the IP network IP). N+1=4 connections L0, L1, L2, L3 of the fast Ethernet type (each with a capacity of 100Mbps) are used. Each of these connections L0, L1, L2, L3 is 55% utilized in this example in fault-free operation. If an edge router ER0, ER1, ER2, ER3 or a connection L0, L1, L2, L3 fails, the payload affected is distributed over the free capacity of the remaining connections L0, L1, L2, L3, which are then 73% utilized.

In a development of the invention, connections EL0, EL1, EL2 can be provided between the edge routers ER0, ER1, ER2, ER3 to reroute the data traffic assigned to this failed interface unit or connection to the edge routers with a functioning interface unit or connection, if an interface unit IF0, IF1, IF2, IF3 or a connection L0, L1, L2, L3 fails. This rerouting (which is local in relation to the edge routers) of the data traffic is generally achieved more rapidly than the rerouting of traffic through the next router level, which is for example formed by core routers CR0, CR1.

Although the invention was described in relation to the interfacing of a media gateway MG with an IP network IP, this invention is not restricted to the exemplary embodiment. The interfacing of a media gateway MG with other packet-oriented networks IP is possible with the present invention. For example, the packet splitters described can operate on the basis of frames of other layer 2 protocols or on the basis of IP packets or on the basis of packets of other layer 2 protocols instead of on the basis of Ethernet frames.

Network elements MG other than the media gateway MG described as an exemplary embodiment, which provide redundant components ES0, ES1 for switching data in a communication network IP, can be interfaced in a fail-safe and similarly cost-effective manner with a communication network with the aid of the invention.

If triple or multiple redundancies are provided within a network element MG, corresponding triple multipliers or multiple multipliers or triple splitters or multiple splitters are used in place of the double multipliers or the double packet splitters.